# RADIOPHARMACEUTICAL CZT SENSOR AND APPARATUS

## CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application No. 61/508,402 entitled "RADIOPHARMACEUTICAL CZT SENSOR AND APPARATUS" filed on Jul. 15, 2011; and U.S. Provisional Patent Application No. 61/508,294 entitled "SYSTEMS, METHODS, AND DEVICES FOR PRODUCING, MANUFACTURING, AND CONTROL OF RADIOPHARMACEUTICALS-FULL" filed on Jul. 15, 2011. The entirety of each of the preceding applications is incorporated by reference herein.

## BACKGROUND

I. Field

Aspects of the present invention relate generally to gamma ray sensors, and more particularly to methods and devices for detecting radioisotope concentration, activity and volume using gamma ray detection with cadmium zinc telluride (CZT) solid state detectors.

II. Background

Diagnostic techniques in nuclear medicine generally use radioactive tracers which emit gamma rays from within the body. These tracers are generally short-lived isotopes linked to chemical compounds which permit specific physiological processes to be studied. These compounds, which incorporate radionuclides, are known as radiopharmaceuticals, and can be given by injection, inhalation or orally. One type of diagnostic technique includes detecting single photons by a gamma-ray sensitive camera which can view organs from many different angles. The camera builds an image from the points from which radiation is emitted, and the image is electronically enhanced and viewed by a physician on a monitor for indications of abnormal conditions.

A more recent development is Positron Emission Tomography (PET), which is a more precise and sophisticated technique using isotopes produced in a cyclotron, where protons are introduced into the nucleus resulting in a deficiency of neutrons (i.e., becoming proton rich).

The nucleus of a radioisotope usually becomes stable by emitting an alpha and/or beta particle (or a positron). These particles may be accompanied by the emission of energy in the form of electromagnetic radiation known as gamma rays. This process is known as radioactive decay.

A positron-emitting radionuclide is introduced into the body of a patient, usually by injection, and accumulates in the target tissue. As the radionuclide decays, a positron is emitted, and the emitted positron combines with a nearby electron in the target tissue, resulting in the simultaneous emission of two identifiable gamma rays in opposite directions, each having an energy of 511 keV. These gamma rays are conventionally detected by a PET camera, and provide a very precise indication of their origin. PET's most important clinical role is typically in oncology, with fluorine-18 (F-18) as the tracer, since F-18 has proven to be the most accurate non-invasive method of detecting and evaluating most cancers. Fluorine-18 (F-18) is one of several positron emitters (including also, Carbon-11, Nitrogen-13, and Oxygen-15) that are produced in a cyclotron and are used in PET for studying brain physiology and pathology, in particular for localizing epileptic focus, and in dementia, psychiatry and neuropharmacology studies. These positron emitters also have a significant role in cardiology. F-18 in FDG (fluorodeoxyglucose) has become very important in detection of cancers and the monitoring of progress in cancer treatment, using PET. A radioactive product such as F-18 in FDG is a specific example of a radiopharmaceutical.



F-18 has a half-life of approximately 110 minutes, which is beneficial in that it does not pose a long-term environmental and/or health hazard. For example, after 24 hours, the radioactivity level is approximately 0.01% of the product when freshly produced in a cyclotron. However, transport time from the production source to clinical use should be minimized to retain a maximum potency for accurate diagnostic value.

Whereas PET cameras are effective in imaging uptake of F-18 present in administered FDG, PET cameras are generally too large and ineffective in production settings where characterization of the source product, and not physiological response, is the goal. There is a need, therefore, for a method and apparatus to timely calibrate the radioactivity of a sample at the production source and time of production or packaging for delivery so that the level of radioactivity is predictably known at the time of use.

## SUMMARY

The following presents a simplified summary of one or more aspects of a method and apparatus for detecting radioisotope concentration, activity and sample volume.

In one example aspect of the invention, a gamma ray detector may include a gamma ray detecting rod elongated in one direction to a specified length, and a gamma ray shield encapsulating the rod, the shield having an opening opposite an end of the elongated rod to admit gamma rays substantially parallel to the long axis of the elongated rod, wherein the long axis of the rod and the opening are directed toward a volume of gamma ray emitting material observable by the detector on the basis of the length of the elongated rod and the opening in the gamma ray shield.

In another example aspect of the disclosure, an apparatus for detecting a volume concentration and activity of a radionuclide content in a container includes a container of known dimensions for receiving the radionuclide. A first gamma ray detector is arranged below the container with respect to gravity and directed toward the container. A second gamma ray detector is arranged above the container with respect to gravity and opposite the first gamma ray detector, and directed toward the container. Detection circuitry and a processor are coupled to the first and second gamma ray detectors, wherein the processor is configured to measure radiation intensity received at the first and second gamma ray detectors and determine a level of content of radionuclide in the container on the basis of the radiation detected by the first and second gamma ray detectors.

To the accomplishment of the foregoing and related ends, the one or more example aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative aspects of the one or more aspects. These aspects are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed and the described aspects are intended to include all such aspects and their equivalents.

## BRIEF DESCRIPTION OF THE DRAWINGS

These and other sample aspects of the invention will be described in the detailed description that follow, and in the accompanying drawings, wherein: